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Developing a System of Screen-less Animation for Experiments in Perception of Movement

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Abstract

Experiments that test perceptual illusions and movement perception have relied predominantly on observing participant response to screen-based phenomena. There are a number of inherent problems to this experimental method as it involves flicker, ignores depth perception and bypasses the proprioceptive system, in short it is psychophysically distinct from dynamic real life (veridical) perception. Indeed there still is much disagreement regarding perception of apparent (screen- based) motion despite the fact that we view it in a myriad of ways on an everyday basis. With the aim of furthering our understanding and evaluation of veridical movement perception, the team sought to develop a replicable technique that included embodied, multi-sensory perception but eliminated the screen. They approached this by taking time-based techniques from animation and converting them to the spatial; grouping static objects according to Gestalt principles, to create sequential visual cues that, when lit with projected light, demand selective attention. This novel technique has been called the 'diasynchronic' technique and the system; the 'Diasynchronoscope'. The name Diasynchronoscope comes from combining diachronic, (the study of a phenomenon as it changes through time) with synchronous and scope (view). In being so named, it evokes the early animation simulators such as the phenakistoscope and the zoetrope, regarded as direct ancestors of the project in acting both as art objects and experimental media. This paper documents the creation of this new, experimental medium in choreographed time and discusses its potential as a novel tool for investigating aesthetics in movement.

Categories and Subject Descriptors (according to ACM CCS): I.3.3 [Computer Graphics]: Picture/Image Generation—Line and curve generation

1. Introduction

The problem with screen-based kinetic experiments in attention and movement is that they can be psychophysically different to veridical perception of dynamics.

The foundation of all our present knowledge of visual perception of motion is Max Wertheimer's empirical study of apparent movement and the Gestalt founder's discovery of the phi phenomenon a century ago [Wer12]. 'Apparent movement' is the perception/illusion of movement, although nothing actually moves or changes position in time, such as how we perceive film running at 24 frames per second as a 'moving picture'. These early experiments were not screen-based, (Wertheimer apocryphally used a toy-train and strips of paper) although subsequent reporting by historian of psychology, Edwin G. Boring in his book, *A History of Experimental Psychology* (1950, original 1929), describes them as isomorphic to phenomena that 'occurs in the stroboscope or in the cinema' [Bor50]. Wertheimer employed real life objects lit continuously or used controlled durations of slide projected light from a tachistoscope for his experiments. Although perceptions of apparent motion and real motion clearly share similar physiological correlates, there is no certain proof of complete isomorphism between the two cognitive perceptions, and considerable evidence for there being some differences. Indeed Wertheimer himself appeared to be aware of the lack of isomorphism in some cases and suggested studying the conditions that produce non-correspondence between the percept and the aspect of the real world that it maps [LL99].

One illustration of the difference can be found where the frame rate is too slow on TV or in movies to represent accurate physical movement of rapidly moving objects.

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A well-known consequence is the wagon-wheel illusion, in which wheels appear to be turning backwards. The initial discovery that a perceptual experience akin to the familiar wagon-wheel illusion in movies and on TV can occur in real life and without stroboscopic presentation led to some wonder [Kli04]. However subsequent analysis showed that there were significant differences in the two perceptions, not least that in continuous light, the illusion takes many seconds, or even minutes to develop, and is limited to between 2 and 20Hz, whereas the stroboscopic effect is immediate and not limited to this narrow band of presentation [AP05, Van06].

With the latest improved stereoscopic 3D projection technology it might be thought that some of the psychophysical differences would be removed, however as recently pointed out by Richardt *et al.* there are still many problematic areas [RSDD11]. The absence of motion parallax [How11], and vergence accommodation depth conflicts [Hof08], caused by the need to focus on the screen instead of a virtual point in 3D space are just two physiological areas that are compromised alongside a handful of others, not least the need for vision glasses.

Michael Wertheimer (son of Gestalt Founder Max Wertheimer and himself an eminent psychologist) remarked in a recent interview with David Peterzell on *Gestalt Psychology* (from 2010) that: ‘A simple computer model of Gestalt phenomena may be almost inherently impossible’ (refer also to Michael Wertheimer’s writings on Max Wertheimer, *e.g.* [Wer91]).

This question of how to recreate Gestalt experiments in perception in an embodied ‘real’ world environment has led us to conceive a new way of looking at attention in perception, communication and embodied action using the diasynchronic technique. Before computers, tachistoscopes were used extensively in psychological research to present visual stimuli for controlled durations, (you will recall that Wertheimer sometimes used the tachistoscope for his experiments) however the challenge with a tachistoscope is that whilst it allows images of great fidelity and size, it is limited to a single image per projector, obviating research into time-based imagery.

The Diasynchronoscope takes old techniques of experimenting with apparent movement and brings these to the digital age by relying on three modern software tools: (i) a 3D content generator, (ii) an image manipulation tool, and (iii) a digital movie management platform. After constructing an animation in virtual 3D, a concrete system is created where real three-dimensional objects are placed in a blackout space and projection mapping is used to light the objects selectively and sequentially. The result is screen-less animation of real 3D (static) objects that are lit with continuous light for selected durations.

In this paper we document the creation of this new medium as an artwork and as a potential experimental tool for perceptual studies on apparent object motion. As well as documenting the process, we describe some of the inspirations, research, problems and design solutions encountered on the way. We also include observer feedback on the experimental artworks created so far. We hope to have created a medium that:

- is screen-less
- is veridical, in terms of perspective, focus and parallax
- eliminates flicker
- explores transient cues in apparent motion
- is replicable
- is unique and offers a new experience to audiences

The Diasynchronic technique came about through a unique artistic trans-disciplinary collaboration between a designer/artist, an animator/artist and a computational scientist who wanted to explore theories of attention and movement. The trans-disciplinary nature of the project is reflected in this paper, where the technical terminology of animation and computation will be used where possible; however taxonomic language from perception theory is also included in brackets alongside.

1.1. The physiology of perception

Why, when we look at a succession of still images on the film screen or television, do we see a continuous moving image? Even today there is no consensus in answering this question. Early postulates were for persistence of vision being eye-centered not brain-centered where images ‘lag behind’ on the retina, creating an overlapping image, and many media textbooks still propound this solution despite Wertheimer’s 1912 paper on apparent motion where he describes phi and beta movement.

In their paper on the *persistence of vision* Joseph and Barbara Anderson took a second bite at trying to scotch the myth of such persistence once and for all [AA93]. Their opinion is that the myth is perpetuated by media and film theorists who wished to adopt a Marxist approach in discussing the audience, *i.e.* treating them as passive and sluggish receptors of film. Although philosophers in media may not have caught up most cognitive psychologists subscribe either to Wertheimer’s phi and beta movement as an explanation or to the idea of apparent motion being, in fact, equal to real life motion.

Wertheimer’s monograph on perception of apparent motion included his discovery of ‘phi’ movement as being distinct from ‘beta’ movement [Wer12] but, due to mistakes in translation this phenomena has proved fairly elusive to replication over the years. There is an excellent discussion of this history by Robert Steinman and Zygmunt and Filp Pizlo in 2000 [SPP00]. The authors felt it was significant that controversy still surrounds the differences between these two phenomena, phi and beta movement in media literature and psychology papers, and list a number of erroneous textbook examples. The two are however, demonstrably distinct in visual terms and probably distinct in physiological terms as demonstrated by Pizlo in his online monograph study: Magni-Phi and related phenomena [Piz].

The experimental psychologist Braddick argued for a perception being, 'under certain conditions' a pure bottom-up process [Bra78] and psychologist Richard Gregory argued the case for perception being a top-down, problem-solving process. [Gre97]. Braddick more recently puts forward the view that perception is a dual process (top-down and bottom-up) depending on stimuli.

The idea that apparent motion is isomorphic with real motion is largely predicated on fMRI studies made of subjects as they watch film, such as those made by a team in Denmark which show that the pathways and processing of real and apparent motion in the visual cortex reveal similar activity [Lar06]. They take this to indicate that we perceive film very much as we perceive real life, although it should be noted that these studies involve biological motion, not object motion.

The Andersons' paper similarly rejects phi movement as an explanation and argues that because neural research suggests that viewers process motion in a motion picture very like the way they process motion in the real world [KP71], we should instead adopt the term 'short-range apparent motion' for the phenomenon [AA93]. (Long-range being widely spaced stimuli that are too far apart to create continuity of movement and short-range being stimuli spaced close enough to achieve animation.) There is yet further controversy between the idea of persistence of vision and 'short-range' and 'long-range' apparent motion [AA93]. It seems extraordinary that a full century after Max Wertheimer wrote of these phenomena, there is still no proven common ground.

As artists we could not help but remark that these controversies run alongside film makers, animators and designers working in the medium. There seemed to be an argument for looking at how the practitioners have approached making pictures 'move'. A significant study in helping to shape this thought was Marchant, Raybould, Renshaw and Stevens 3-year eye-tracking evaluation of dynamic scenes in Hitchcock's film, Vertigo, a study that led Marchant to conclude [MRRS09]:

> The visual experience, or where the attention is drawn, appears to be highly controllable or subject to manipulation through directorial techniques such as the use of deep/shallow focus, approaches to editing, graphic matching and camera movement.

To sum up, there is an enormous amount of disagreement regarding the perception of apparent movement. There is no definitive version, and a proliferation of disinformation on the subject, despite the fact that millions of people have been happily viewing apparent motion in a myriad of ways on an everyday basis for over a century. This much we know: apparent motion exists and excites some of the same brain areas as perceived 'real' motion.

Psychologists have also established that change can only be perceived through attention [vdH03, MR00] and corresponds to the way our visual cortex divides and processes four separate parallel pathways of perception: form, colour, movement and depth. Gestalt principles, animation and film techniques rely on our systems endowing a continuity of perception to objects that displace within corresponding graded constraints of shape, colour, motion and mass. Quantifying these graded constraints to define parameters for short-range and long-range apparent motion, illustrating phi and beta movements in the real world and creating an aesthetic comprehension of how transient cues can alter how we feel, are areas that are yet to be fully investigated.

1.2. Old and new tools

The project does not just adopt the early tools used in experimenting with apparent movement such as using the consistent light of the tachistoscope; it also adopts the concept of combining experimentation with creation of artworks within the medium, using observation of audience and their feedback to help guide exploration.

Figure 1: *Very first bounce being set up*

Although the technique used in the Diasynchronoscope project seems to hark back to early animation techniques, it would be impossible to create sophisticated models without the modern computer softwares of 3D visualisation and video editing. The three modern software tools we used were Autodesk's 3ds Max and Adobe's Photoshop and After Effects programs; other similar tools could be used. 3ds Max was used to visualize the experiments before building and Photoshop was used to plan the sequential animation and for mapping the projection. The selective masks created in Photoshop were sequenced into a movie with synchronized sound in After Effects. And finally the sequence was exported in a standard movie format; as a Quicktime movie to run through the projector.

We will explain the methodology in more detail in §3, but first would like to try and convey some of the excitement and thought processes in the creation of the medium by describing the first experiments. Our very first attempt at the medium was of a polystyrene cube bouncing in a (not very good) black out space (Fig. 1).

However, we saw enough 'magic' in the way it 'moved', (and in the fact that we could move around it) to think we should attempt the technique on a larger scale and, in the spirit of the early Gestalt founders, invite observers to empirically test the result.

2. Audience response: Experiment 1

> "The same subject seen from a different angle gives a subject for study of the highest interest and so varied that I think I could be occupied for months without changing my place, simply bending more to the left and the right". — Paul Cezanne (Post-impressionist artist)

The 'swing and bounce' was our first public experiment with the Diasynchronoscope medium. As we were interested in it primarily as an embodied experience, we decided to show it to a varied group of people and record their individual responses to the artwork using observation and semi-structured interviews. We did not quite know what to expect or if we had overcome enough practical problems for the medium to 'read'.

Video of the non-participant observation and semi-structured interview can be seen on our project website — [Dia12], page: "Experiment 1: Swing and Bounce". The viewings revealed that the medium was 'reading' well, and subsequent analysis of the interviews led to some new exploratory questions and ideas for art, particularly in linking it to Gestalt theory.

We visually and psychologically attempt to makeorder out of chaos, to create harmony or structure from seemingly disconnected bits of information. How we best receive this information and arrange it is governed by a fundamental to Gestalt theory: the 'law of Prägnanz', the German word translates as salience, conciseness, impressiveness, or orderliness.

The most important notion in Gestalt is that the whole may carry a different and altogether greater meaning than its individual components. For instance, imagine how a film is so much more than a sum of its parts: shots, scenes, montages, sound, music, dialogue, actors, film stock, projector and light and screen. In viewing the "whole," a cognitive process takes place – the mind makes a leap from comprehending the parts to a meta-realization of the whole.

It became clear that each participant was bringing their own schema to the movement and that the piece was appreciated with three different 'modes' of perception; as a

Figure 2: *Is this a picture of a duck facing right or a rabbit looking left? The duck-rabbit illusion is a typical Gestalt illusion of 'multistability'*

'moving' object in time, as a series of individual objects and as an holistic 'single' object. The viewings revealed a remarkable similarity to the Gestalt illusion of multistability. It is striking that the three modes are at once compatible and incompatible perceptually. Rather like the Necker cube, or Duck/Rabbit illusion, it seemed that we had most commonly created a ball/sponge/dinosaur spine illusion (Fig. 2).

It is too early to draw conclusions from this, but we are not aware of many other multistability examples that take place across time and this would be an area worth exploring. All great artworks work on more than one level and if the three modes were artistically linked, perhaps we could achieve a Gestalt oneness, a prägnanz for future experimental artworks?

Most importantly, we discovered that the medium 'read', the three-dimensional depth was working, there was a haptic desire to touch the piece and people were experiencing it as something new. The absence of flicker and the use of sound were creating a new sensation that was embodied. That they found the movement readable could be attributed to the animation principles of squash and stretch, timing, synchronous sound, and arcs, but also could be attributed to Gestalt principles.

2.1. Animation and Gestalt

Motion in animation cannot be discussed without referring to the twelve animation principles first espoused by the Disney studios in the 1930's and still going strong today. Although the principles are particularly relevant to character animation, many of the principles apply to creating believable object animation too. The twelve are:

1. Squash and Stretch
2. Timing
3. Anticipation
4. Staging
5. Follow Through and Overlapping Action
6. Straight Ahead Action and Pose-To-Pose Action
7. Slow In and Out

8. Arcs
9. Exaggeration
10. Secondary Action
11. Appeal
12. Personality

Animation principles serve as a helpful aesthetic reminder to an animator of things to consider when creating and revising animation. Principles such as 'timing, appeal and personality' are too general for a non-technician to find useful.

In her 2007 paper, animator MacGillivray argued for including at least one other principle: that of 'Isolation' [Mac07]. Isolation refers to centralizing a character and their movement for the sake of attention. If one character is gesticulating wildly in a scene, you don't want another to join in or the viewer's eyes will shift away from the main action.

An updating of the principles, translating their application to 3D computer animation was explored by Pixar founder, John Lasseter in his much cited 1987 Siggraph paper [Las87]. The first and generally acknowledged most important principle is that of 'Squash and Stretch'. Lasseter discussed this principle not just as a desirable, indeed essential, principle for animating facial movement but also for the way squash and stretch and overlap can be used by an animator to relieve the disturbing effect of strobing that happens sometimes in depicting very fast motion. The unwanted strobe effect occurs if the distance an object moves between frames is so fast that there is no overlap and the eye begins to perceive separate images. There are a number of ways an animator would deal with this problem – in computer animation we would add blur, in model animation we would never move an object beyond its previous silhouette and, as Lasseter indicates, in drawn animation we would stretch the figure [Mac07]. This interpretation of how overlap avoids strobing had implications for the diasynchronic technique and also sheds some light on short and long range apparent motion.

For the Diasynchronoscope, as we were taking objects that animated in time and translating them to space, in some ways it felt as though we were mapping animation principles onto Gestalt principles. Gestalt principles are not limited to static visuals, they include motion, and auditory Gestalt too. The principles particularly relevant to our project and movement are:

Figure/Ground articulation this principle denotes our perceptual tendency to separate whole figures from their backgrounds based on variables, such as contrast, colour, size or movement. The animation principle of Staging and, in terms of movement, MacGillivray's notion of Isolation would both map to the figure/ground articulation principle. By lighting objects crisply in white against a black background we are demanding an observer's attention through Figure/Ground articulation.

Similarity Principle things which share visual characteristics such as shape, size, color, texture, or value will be seen as belonging together or 'grouped' in the viewer's mind. The forms need not be entirely identical – there may be variety within the repetition, yet the correspondence will still be discernible. Animation use of squash and stretch means that we carry the continuity of an object through, although it may be morphing in shape. The principle was clearly demonstrated by the universal observation: 'it bounced'. Even though there was multistability, within each pattern there was always a consistent object.

Common Fate Principle elements tend to be perceived as being grouped together if they move together. This is an extrapolation of the visual grouping of the similarity principle to movement, and so is often left out of design books that are only interested in visuals, not dynamics. Think of chorus girls dancing in a line, waves on a beach or wind blowing across fields of wheat. This corresponds to animation principles Follow Through and Overlapping Action and Secondary Action. In our experiment the objects did not become grouped together until they were all revealed at one time, when for many participants the artwork became something akin to a dinosaur spine (Fig. 3).

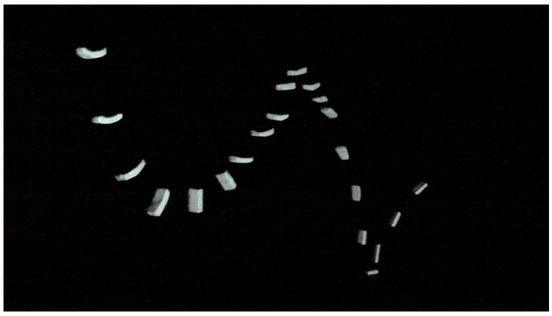

Figure 3: *' The holistic swing and bounce' now appears as a 'dinosaur spine' to many participants.*

Closure Principle our brains are so drawn to patterns that we tend to complete figures even when part of the information is missing. Closure occurs when elements in a composition are aligned in such a way that the viewer perceives that the information could be connected, and the eye understands something as being part of the composition even though there is "nothing" there. Film and animation audiences suspend their disbelief and immerse themselves in a two-dimensional experience enhanced only by sound. To quote the film theorist and perceptual psychologist, Rudolf Arnheim:

> "In order to gain a full impression it is not necessary for a film to be complete in a naturalistic sense - all kinds of things can be left out which would be present in real life so long as what is shown contains the essentials." [Arn74]

The example Arnheim gives is of viewing a black and white silent film: how if all the colour were to be drained from our world we would be shocked; yet audiences have happily participated in and enjoyed the spectacle of black and white (and silent) movies. In the experiment patterns were noted and recognized, but most importantly, smooth movement was strongly perceived although nothing actually moved.

Good Continuation Principle this governs how oriented units or groups are integrated into perceptual wholes if they are aligned with each other. We tend to continue shapes and lines beyond their ending points, and so meet up with other shapes or lines, particularly if the path followed by our eyes is smooth. This is crucially very similar to the use of arcs in animation and was fundamental to much of our experimentation.

Past Experience (familiarity) Principle this is where elements tend to be organized together if they were grouped together in the past experience of the observer. We observed examples of this in the different schemas brought by participants (bouncing bomb, tennis ball, dinosaur, kitchen sponge)

Gestalt principles have been revisited and renegotiated not only by artists and designers such as Tufte [Tuf97], but also cognitive neuroscientists over the years, including the neurologist Ramachandran who created his own nine laws of aesthetics [Ram11] and the founder of neuroaesthetics, Semir Zeki, who turned to aesthetics after his studies in integration in visual agnosia. [Zek93, Zek02]

Every principle is accessible through overlapping sensory perception and it should be possible to apply them to complex images in time and, as a result, produce a hierarchical parsing of its content that corresponds to our perception of its wholes and sub-wholes. This has still not been accomplished via computational models with satisfaction.

3. Methodology: Set up

Previous work by a member of the team (website: [Dia12], "About us" page, Bruno Mathez) had shown that in order to achieve selective, attention-demanding projection we needed to project into a dark space. For optimization in rendering the objects invisible unless lit, the space needed to be in complete black-out and the objects painted matt black. Initial models were made in a metal gazebo hung with matt velvet black-out cloth.

To fully illuminate the space with projected light, the team selected used a short throw lens video-projector, 0.719-0.79 (63"@1m) which allowed positioning nearer to the black-out space, ensuring that any object placed could be illuminated with projected light and that the pixel size would be sufficient for mapping. The video projector needs to have a good contrast ratio, of at least 1/10,000.

If the contrast is not high enough the black pixels are too luminous and reveal the surrounding objects in the dark, which needs to be avoided for good figure/ground separation.

The next phase was to work out how the selectively illuminated objects could be lit sequentially to create simulated movement. We made a 3D virtual version of the movement using Autodesk 3ds Max. This allowed freedom of experimentation with the animation path, the shape of the animated object and the number of objects needed to create the movement. The animations were made as normal 3D animations, shot at 12 frames per second (fps) in PAL format. The choice of 12fps was a deliberate animation technique: Normal film in the UK runs at 24fps and as animation is an arduous process, animators have always looked for short-cuts. It is common for less expensive TV animation to use 'shooting on twos' or double up each frame, as animation will mostly still read at this speed and the sacrifice in quality can be perceived as negligible against doubling an animation budget. It also means that you can be flexible in places where 12fps is too coarse and change up to 24fps for specific fast movements. There was concern that the result may feel jerky, but empiric evidence showed this was not the case.

Because a major aim was to study pure movement, an early decision was taken to make the objects as emotionally neutral as possible. We also felt after some experimentation that at this stage, we wanted to preserve the integrity of lighting each object with a pure white light that held no animated projection; this is because animating projection on top of objects holds a different and distinct 2D aesthetic.

To keep the object neutral and easy to create, we started working with a cube (moving on later to an oblong box and then to tapered, round coffee cups). Although using a cube, the decision was made to use a 'bounce' animation. This is because it is an elemental building block in an animator's repertoire.

The first models included overlapping objects at each

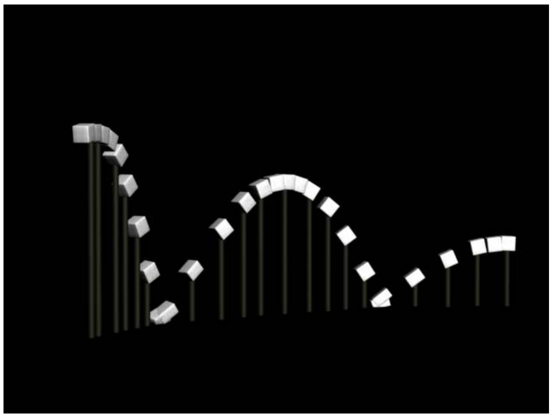

Figure 4: *A sample bouncing of a cube*

'bounce' (Fig. 4). Initially this felt like a creative solution to translating time into space and created a detour in experimenting with lighting overlapping objects. However this led to technical difficulties as they were hard to light with the integrity we envisaged.

Inserting a 3D camera into the scene in 3ds Max meant we could select the best position for placing viewers. This point-of-view (POV) was critical in the early versions as we were limited to a narrow range of deviation on the x and y axes for the viewer's POV. Another consideration that determined the viewing angle was how the video-projector illuminated the objects: in order to avoid lighting a single flat plane and thus lose the effectiveness of using real three dimensional objects, we tried not to position the objects perpendicular to the light beam because only one side of the object would then be illuminated. Best positioning occurs when the video-projector illuminates three sides of the object, revealing the three dimensionality of the object in space. (This constraint might be eliminated if we were to use a second video-projector to light the other side of the objects, acting as a fill light.)

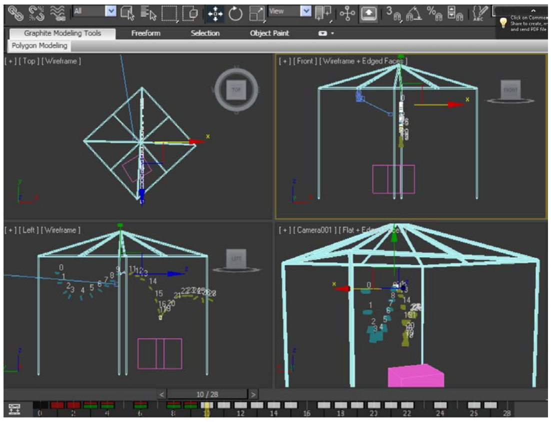

Figure 5: *Four view template of the first model from with 'ghosted' objects showing in 3ds Max*

Once the viewing angle had been chosen, we exported the animation path from Autodesk 3ds Max as a still image where each position of the object and its morphing shape was visible along a path. This was done using the 'show ghosting' option in 3ds Max, which also allowed us to number each block (Fig. 5). These images served as our template for our model and for creating the individual objects that would be lit in the Diasynchronoscope.

The dimensions for each object was calculated by comparing the maximum size of the black-out space with the maximum length of the animation path and created the objects according to our guiding template.

After some experimentation with a variety of materials (plaster, plastics, paper) we decided that an ideal cheap, light and easily-shaped material would be polystyrene. We

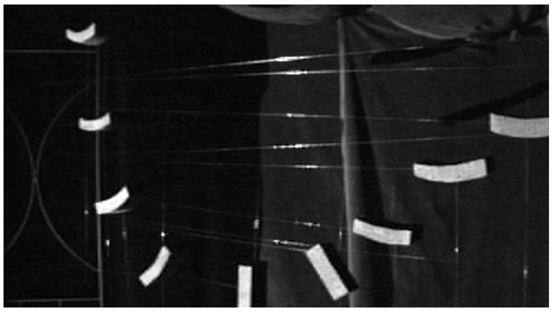

Figure 6: *Polystyrene objects hung on fishing line for the first experimental model 'swing and bounce'*

numbered each object according to its position along the animation path and cut smaller blocks from large 6 inch thick blocks of polystyrene, using a hot-wire cutter to create a standard character block (in animation terms a 'hero' model) and also create more organic, bent block shapes that included animated Anticipation, Follow-through and Squash and Stretch principles. After the cutting process the objects were painted with matt black paint, to make them invisible unless lit.

Using the template images as a guide, the numbered objects were arranged in the black-out space with a variety of positioning techniques.

Figure 6 illustrates stringing the objects on fishing line fine enough to be invisible when painted black (not yet done in the picture). We fitted a vertical and horizontal fishing line through each object in order to stabilize them and make them look as if they were floating in the space. A more efficient second technique for the objects close to the ground was to spear them onto wooden sticks — painted black to be rendered invisible — these we fixed by inserting them in a thick layer of black-coated insulation foam on the floor. Later we became bolder with our use of sticks and we also used blocks of insulation foam fixed vertically using horizontal sticks to hold the objects (Fig. 7).

3.1. Methodology: Projection mapping

Once the objects were arranged in the black-out space we moved on to the phase of projection mapping. As the diasynchronic technique is a technique to illuminate each object with plain color, not to project a pre-established design into a projection surface, we did not need to take into account the distortion criteria and so we created simple two-dimensional masks using Adobe Photoshop in a two-screen system: a full screen output on the video projector and a zoomed-in screen on the laptop. This double-window set up specific to Photoshop gave us the ability to refine the mask on the laptop screen at a pixel level while it was being projected onto the objects, allowing us to react to how small changes affected

Figure 7: *Polystyrene objects fixed using wooden skewers painted black and stuck in foam. This is from the third experiment 'Gestalt Circle'. The numbers describe the four beta pathways*

the overall illumination. We worked with the maximum resolution provided by our video-projector (1920 x 1080 pixels). For example, if we were to illuminate twenty objects, the maximum amount of colored pixels used to illuminate each object could not exceed 96 x 54 pixels.

The size of each pixel depends on the distance between the video-projector and the objects and therefore on the size of the black-out space. In order to increase the quality of the experience we needed to ensure that the pixels were not too big for the objects. If the pixels were too big, they could cover the object but also spill outside of the object, creating a bleeding artifact of light on the back wall of the black-out space. In these early models, it proved sometimes impossible to avoid this bleeding effect

Once the mask was created for each object we imported the Photoshop layers into Adobe After Effects. We use this software for its malleability to work with Photoshop layers, its efficient animation technique features and also because it allowed us to create the animation while remaining at the same resolution and pixel ratio as the original masks created in Photoshop.

The projection mapping technique was the first technique we used to precisely illuminate objects sequentially in real space. We found that the best positioning of the video-projector was at eye level; that way it illuminated the object in correspondence with the viewer POV eye level.

3.2. Audio

It was long known amongst the early Gestaltists that two identical visual targets moving across each other can be perceived either to bounce off or to stream through each other [Met34] and in 1997 Sekuler *et al.* demonstrated that a brief sound at the moment the targets coincide biases perception toward bouncing [SSL97].

As the Diasynchronoscope project was conceived to explore the embodied and environmental nature of perception of movement, and the team had a keen interest in synchronized sound, it was felt essential that the artworks incorporated sound, although it was not always construed as necessary for the experiments in apparent movement.

An interesting consequence of sound use can be found in the third experiment where the sound decisions were reached almost intuitively to come from either end of the digital/analogue spectrum. The beta movement consisted of organic, holistic and embodied swooshes created orally and the phi movement was synched to castanet clicks that emphasized the different qualities of perceived movement.

4. Experiment 2: Phi and Beta

> 'It is not important what goes on each frame of film; it's the spaces between frames that are important' — Norman McClaren, Canadian Animator [Sol87]

The phi movement circle is an experiment in creating movement that is attention-less. We were interested to see if the phenomenon might change when viewed with no screen and if the absence of flicker would impact on perception. At this stage there seems to be no discernible difference between this screen-less version and Filip Pizlo's study in his whimsically titled screen version: 'Magni-phi'[Piz00]

The single line of objects being animated at different intervals, speeds and spaces was a similar experiment in reproducing some of Wertheimer's observations. We also wanted to take a deeper look at the Andersons' idea of short-range and long-range apparent movement. The experiments can be viewed at our project website ([Dia12], page: "Experiment 2: Phi Movement circle").

There were some things that seemed promising in these experiments, in particular when we experienced a 'spin' illusion with three blocks being illuminated, however there is no conclusive evidence as yet that the medium is impacting on perceptual experience of phi and beta.

4.1. Experiment 3: Gestalt Circle

> 'When principles of design replicate principles of thought, the act of arranging information becomes an act of insight.' — Edward R. Tufte, Visual Design guru [Tuf97]

The third experiment sought to combine the two existing experiments in one artwork. Here we really wanted to look at the differences between phi and beta apparent motion. The artwork was shown at Kinetica Art Fair 2012 in London to approximately 1500 people.

The following is an example of how the participants were guided in voice-over through the experience.

> There is no screen and no actual movement occurs in the chamber. Instead real three-dimensional objects (polystyrene cups) are placed in the scene and then lit selectively and sequentially by white light from a projector. The cups have been arranged by translating motion in time to position in space. When a cup is lit, we cannot help but give it attention. When the cups are lit sequentially; we cannot help but perceive movement. This is because our brains are geared towards perceiving movement, so it fills in the gaps. In Gestalt Circle the brain fills in the gaps in two ways as beta and phi movement. Beta movement is where the eye attends to a cup travelling in a smooth arc. This is exactly the principle of Gestalt continuity that governs the way we perceive animation and film running at 24 fps as 'moving pictures'. Phi movement is where the attention is drawn not to a cup, but the gap between the cups. Because this is object-less perception of movement, it was dubbed 'pure' movement by Wertheimer, although it is far from context-less as although the object of attention is not-an-object, the gap is contextualised by the surrounding objects (in this case, cups). You can identify phi movement by the clicking sound that accompanies it in the video. Here you are following not-a-cup or the gap between cups in phi movement.

Although the two ways of perceiving movement may appear superficially similar, the two states of perceiving movement are physiologically distinct; we cannot follow/ attend to a cup and follow/attend to not-a-cup at the same time, so like the 'Necker' cube, we are caught in a multi- stable perception of movement. Multi-stable perception is the tendency of ambiguous perceptual experiences to pop back and forth unstably between two or more alternative interpretations. The artwork highlights the perceptual transitions made by the brain as it travels from phi to beta and back again, an illusion dubbed 'multistable' perception. One major difference in perceiving phi movement is that it is experienced as a sequence of stills rather than as a continuous moving image – the cups appear to make staccato leaps across a gap rather than travel smoothly. This is consistent with Wertheimer's published monograph on apparent motion in 1912 and Steinman's re-examination of the phenomena published in 2000 [Wer12, SPP00].

Gestalt Circle was a meditation on animating through selective attention that opened up the concepts of phi and beta to an audience brought up on screen-based imagery. The response was enthusiastic and everyone saw the two states of phi and beta.

Feedback indicated that the concept of how their attention could be universally manipulated was new and interesting to many people. Again the movement and sound 'read' and we witnessed a repetition of the haptic desire.

The video can be viewed at our project website ([Dia12], page "Experiment 3 — the Gestalt Circle").

5. Conclusion

The paper investigates the creation of new tool for investigating the expressive power of embodied, screen-less animation. It demonstrates experimental uses of this tool in furthering our comprehension of perception of movement using Gestalt paradigms. To shape our artistic exploration, we revisited Gestalt and animation principles and, although well-versed in using modern software tools, we tried to find ways of integrating them practically with the early experimental techniques for investigating apparent movement that used a consistent light source.

As artworks, the medium seems to offer a unique and new experience to audiences. Although we have used existing techniques, we have combined them in such a way that they supply a new context for addressing questions in computational aesthetics.

There are certainly compromises in the medium as it stands: the animations needed to be swift and dynamic enough to avoid occlusion of one object against its neighbor: this currently eliminates more nuanced animation. So far we have also only used white light in a blackout space and creating recognizable or colored objects is an area open for exploration.

This is a new medium in its infancy and the question of whether this new technique can resolve some of the arguments re short-range and long-range movement and phi versus beta is still open, but these early experiments in choreographing time look promising. These tests should be replicable because there will be a computational model to follow. Because the medium is screen-less it should be possible to create perceptual tests that are veridical in terms of perspective, focus and parallax without flicker.

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